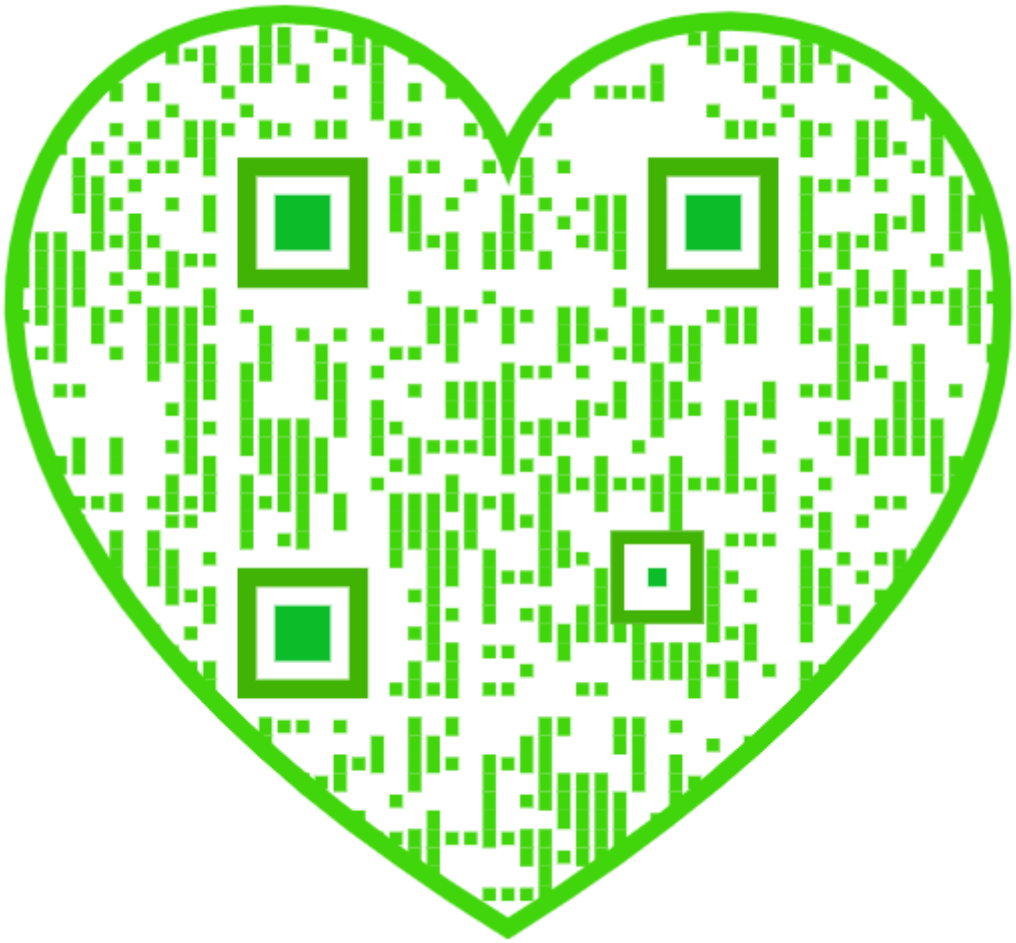
GLUE HANDBOOK

C. B. Christoffersen



GLUE HANDBOOK

A Handbook
For Craftsmen, Concerning the History,
Manufacture, and Correct Use
of Pure Hide Glue

KEYSTONE GLUE COMPANY
WILLIAMSPORT, PENN.

Manufacturers of PURE HIDE GLUE Exclusively

FOREWORD

THIS booklet has been written with two ends in view: to guide the beginner in the use of hide glue and to allay any fear that may be harbored in the mind of the craftsmen. No pretense has been made of writing a textbook, but the vocational teacher should find it very valuable for supplementary instruction in manual training courses.

When it is used in conjunction with these courses, particular attention should be directed to the simple variables—*concentration, temperature, time,* and *pressure.* These variables represent the Alpha and Omega of both the manufacture and use of hide glue. To really know hide glue—and how to use it—is to become thoroughly familiar with the effects caused by these four simple variables.

The material is presented briefly—in fact, a considerable portion of it is arranged in outline form. The extent of the subject makes this a necessity. However, it is hoped this booklet may furnish the incentive for a truly adequate treatment of hide glue—one which will give cognizance to the universal respect hide glue so well merits.

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GLUE HANDBOOK

CHAPTER I

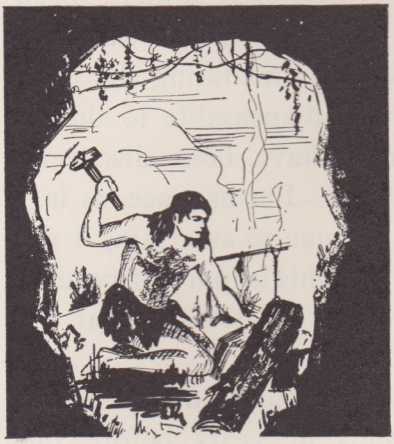
The Early History of Hide Glue

JUST when hide glue was discovered is mere speculation. It is reasonable to assume that it was made and used by pre-historic man antedating the Stone Age. Certainly, a product so indispensable to the development of civilization must have been discovered very early in the life of mankind. Let us trace, as logically as we can, the life of early man to ascertain, if possible, what led to the discovery of this important product, and to see what effect it had upon his development, and consequently upon civilization.

Our pre-historic ancestors were endowed with reason, but it was probably thousands of years before they learned to apply it to their lives. At first, they lived principally upon roots and barks. Later, they accidentally found that flesh was nourishing and that it could be made more palatable by chewing it with their former food of roots and barks. As reason developed into thought, they learned to protect their bodies against the cold by utilizing the hides of their kill. They were beginning to enjoy life. But of far greater importance was the assimilation and collation of this knowledge of

their experiences. These came as a result of the fact that their curiosity was being aroused.

The advent of fire in the life of these pre-historic men was all that was necessary to start a chain of epoch-making discoveries. With their innate curiosity the introduction of fire started them on an upward path that we are still treading. Fire was the "missing link." It was the one thing they needed to fuse many experiences into innovations that produced many useful things. The possibility that hide glue was one of the first of such discoveries made by these simple men has ample theoretical basis.



Few, if any, basic reactions are as simple as the one employed in making hide glue. It is merely an hydrolysis, in the presence of heat, of certain portions of hides and tissues. These pre-historic men possessed all the necessary materials and the agency to bring this reaction to completion. They could hardly have avoided making hide glue. Unwittingly they made it the first time they boiled their meat (no doubt with the skin on it), though they may not immediately have discovered uses for the new product.

When or how they realized they had produced some-

thing of value can only be conjectured. Perhaps it was on their return from a hunt, after an absence of several weeks, that they found their hollow-rock cooking-vessel partly filled with a hard substance and their wood stirring-stick fastened tightly. They no doubt had some difficulty in removing the substance which had been formed from the rich broth by the evaporating and drying effects of the sun. When they chipped this hard brittle substance loose, it was probably thrown on the ground. What must have been their surprise when a night's rain turned this stone-like substance into a soft, sticky jelly! If any of this jelly was put in a dry place and it turned again into a flinty substance, surely surprise must have given way to consternation. What was this piece of magic—that one day was a hard substance—and the next day a soft mass? This certainly would excite their child-like curiosity, and develop a sense of inquiry.

The development of this sense of inquiry opened wide the portals of civilization to these early men. The discovery of this product which we know as hide glue may very reasonably be considered to have been the first of a series of revolutionary advances. Whether or not these pre-historic men found a use for hide glue immediately we can only guess. Archeological discoveries lead us to believe, however, that hide glue was first used by these men as a vehicle for the bright-colored paints used in decorating, and not as an adhesive. Cave drawings in bright colors attributed to men living 20,000 to 30,000 years ago have been found, in which, no doubt, hide glue

Hide Glue in Use during Ancient Egyptian Period.

was the vehicle. The making of something ornamental would naturally spur them on to attempt the making of other, useful things.

It is only logical to believe that these simple men heated other materials or combinations of materials, to satiate their inquisitiveness. One need not stretch his imagination to follow the development of civilization through tanning, ceramics, and metal working. While this development was gradual, extending as it did over thousands of years, it is not to be denied that it was thorough.

From these earlier beginnings we come down to the ancient Egyptians of at least 3300 years ago, who furnish us with the first actual proof that hide glue was known to be a useful product. It must have reached an advanced stage of usefulness by this time, for stone carvings of that date depict the complete art of veneering. The heated glue pot and the brush for application, as well as a flake of hide glue, are plainly carved. In earliest literature passages pertaining to hide glue can be found. So it seems that this important product has been very useful to mankind—even from the beginning.

It is congruous that hide glue should be credited as being the key that opened "the future's portal" and pointed the way to civilization. It was responsible for many important successive discoveries and was in no small degree instrumental in developing the thought processes of these rugged men. As it excited the curiosity of pre-historic man, so it continues to excite curiosity today. The paradox of hide glue is that after thousands of years it still remains a mystery, though the basic man-

ufacturing process is essentially the very same today as it was the day it was discovered.

But the march of civilization has constantly made new demands of hide glue. Each new day seems to bring another use for it. It enters, directly or indirectly, into practically every item we use in our daily routine of living. Hide glue and gelatine (its brother in the flesh) may be said to head the list of "things useful to man." Its innumerable uses have been responsible for making the manufacture and use of hide glue unusually interesting, but necessarily as complex as the civilization it cradled and nursed. This complexity, however, is basically simple, as we shall soon see.

Chapter II

The Process of Manufacturing Hide Glue

THE ancient Greeks were well acquainted with glue—and called it κολλα (Kolla). This old Greek word is interesting because from it two words have been derived which are important in any account of glue. One of these words is *colloid* (glue-like), and is the name given to a chemical family of which glue is a typical member. The other word is *collagen* (glue-producing). It is this name that has been given to the protein which produces glue.

Collagen with other proteins occurs in nature in hide tissue, but to simplify matters it will be considered as occurring alone. When it is heated in water, it is converted into hide glue. This simple reaction is the basic reaction of the hide glue industry. However, the composition of collagen appears to vary. Different types of hides contain collagen of varying nature. If the collagen in these hides of varying types were to be treated with a tanning liquor, the resulting product would be leather. It is known that different types of hides produce entirely different types of leather. It is logical then to assume that different types of hides produce hide glues of varying characteristics. In fact that is just what happens. This point is very important and will be stressed again. It is vital that it be remembered.

If collagen, as it occurs in hide tissue, is the basis of hide glue, it is then correct, of course, to assume that hide glue is made from hide tissue. To get a clearer picture, forget the tissue and just think of hide glue as being produced from hides or, more to the point, from hide pieces. When hides are received by the tanner, they must be prepared for tanning. Parts of them are trimmed off and the flesh side cleaned and evened up. This off-all, of trimmings and fleshings, is raw material for the hide glue manufacturer and is known as hide glue-stock.

There are several classes of this hide glue-stock; and when received by the hide glue manufacturer they are classified, because each class will make a particular type of hide glue. This classification is also necessary because each class will require different treatment to produce these specified types.

It has been stated before that the manufacture and use of hide glue are unusually interesting, but necessarily complex—but that this complexity is basically simple. In truth, the complexity arises from a multiplicity of combinations, of the very simple variables—*concentration, temperature, time,* and *pressure.* To really know hide glue—and how to use it to the best of advantage—is to become thoroughly familiar with the effects of these four simple variables, wherever or whenever they may be applied. Bear them well in mind, as the salient points of the manufacturing processes are unfolded in logical sequence.

A knowledge of skin structure is a prerequisite to an understanding of the treatment necessary to properly prepare hide glue-stock for the extraction of hide glue. Skin is made up of several layers. First, there is the epidermis, which is of an albuminous nature and of no value to the hide glue manufacturer. Separating the epidermis from the corium or true skin, which consists principally of collagen and proteins of a mucinous nature, is a thin glossy-structured membrane. This membrane is of no importance in the manufacture of hide glue but is very important to the tanner because it is responsible for the grain in leather. Under the corium is a layer of fat cells and connective tissue by which the skin is attached to the animal. As collagen is the glue-

Skin Structure.

producing substance, and, as albumins, mucins, and fats are undesirable in the making of hide glue, the first step in the manufacturing process is to eliminate the undesirable constituents.

This process is a combination of "liming," "acidulation," and "cleansing." Lime, a weak alkali, dissolves both albumin and mucin, and renders the bulk of the fat inactive, by saponification, without appreciably reacting with (or hydrolysing) collagen. The liming process also swells the stock, which permits of easier removal of the undesirable constituents, and expedites the acid treatment. This acid treatment, in which a weak acid is usually used, has a twofold result—it shortens the time required for removing the last traces of undesirable salts by further swelling the stock—and, by neutralizing excess lime to some extent facilitates the extraction of collagen in a subsequent process. The cleansing process is simply a washing and kneading of the hide glue-stock in which pure cold water is essential. It should not be looked upon as a separate process, but rather as supplementary to both liming and acidulation, for it is used in conjunction with both.

Careful classification of the hide glue-stock prior to cleansing and treating is very important because there is a marked variation in the hides of different animals, and in different pieces of the hide of the same animal. Some are thin and tender, while others are thick and tough. Treatment that would suffice for the former would be entirely inadequate for the latter, and the more

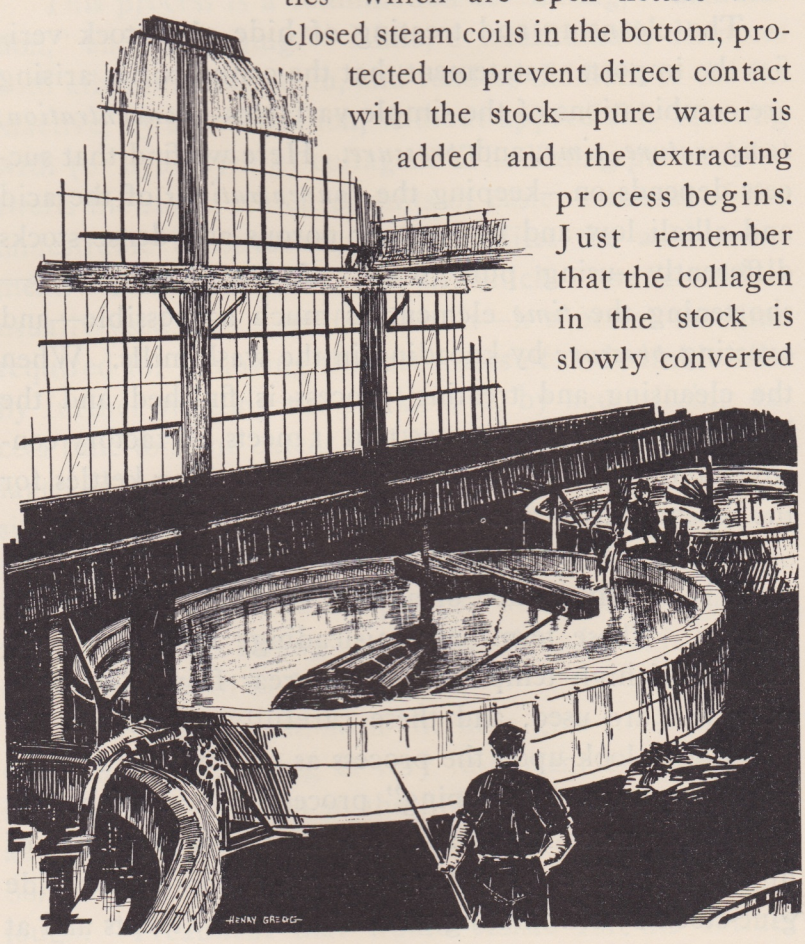
severe treatment necessary to properly prepare the heavier pieces would destroy the glue-producing collagen in the tender pieces. The treatment accorded hide glue-stock depends upon both its type and its condition when received from the tanner.

The cleansing and treating of hide glue-stock verifies the important statement that the complexities arising are combinations of the simple variables—*concentration, temperature, time,* and *pressure.* Here we find that success depends on—keeping the *concentrations* of the acid and alkali low and by treating porous and dense stocks differently—using pure water of low *temperature*—shortening the *time* element as much as possible—and exerting *pressure* by kneading in the wash-mills. When the cleansing and treating process is finished and the hide glue-stock tested to see that it meets all factory control standards, it is transferred to the cooking kettles for the second step in the manufacturing process.

The process of extracting hide glue from hide glue-stock is usually spoken of as the "cooking" or "boiling" process. These terms are misleading; for they imply the use of high temperatures, whereas fairly low temperatures are used, and these carefully controlled. It is better to look upon the process as one of "extracting," or at the most, a "steeping" process. It is, without a doubt, the most important step in the manufacture of hide glue. The preceding process prepares the hide glue-stock by eliminating undesirable constituents and at the same time swelling or opening the stock. But it is in

the "extracting" process that the basic reaction of "hydrolysis" takes place. It is here that hide glue is actually made.

After the stock has been placed in the extracting kettles—which are open kettles with closed steam coils in the bottom, protected to prevent direct contact with the stock—pure water is added and the extracting process begins. Just remember that the collagen in the stock is slowly converted



Wash Mill.

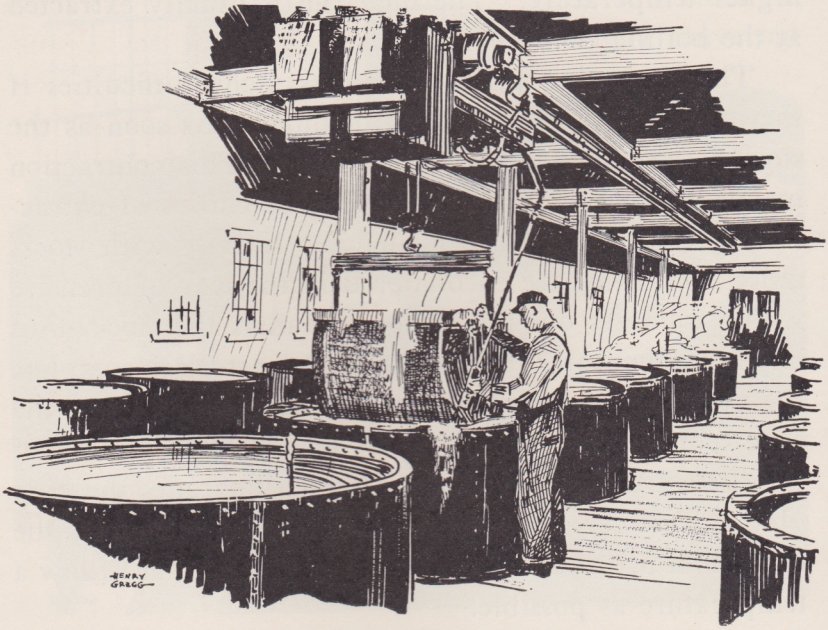
into hide glue merely by the action of heat and water. The heat is applied and maintained at a constant temperature for hours. This starting temperature varies somewhat, and depends on the type and condition of the stock. As the extraction continues, the liquor is tested from time to time, and when it reaches the point where it contains 4% to 5% of its weight of glue, it is drawn off and sent on its way through subsequent processes. More water is then added to the stock remaining in the kettle, and the process is repeated, this time at a raised temperature. The usual procedure is to take off four such *runs,* each succeeding run being extracted at a higher temperature. The final run is usually extracted at the boiling point.

The extracting process presents many difficulties if there is any laxity in control methods. As soon as the stock is heated, it begins to contract. This contraction makes it denser and increases the difficulties of extraction. If the kettles are loaded too heavily with stock, more difficulties are encountered in the way of pressure which squeezes out the liquor and mats the stock, thus impeding the water from reëntering the stock to complete the reaction of hydrolysis, and further increasing the time required for extraction. A secondary hydrolysis of the extracted hide glue liquor, which degrades the hide glue, and lowers the yield, makes it imperative that the extraction proceed as rapidly as possible and at as low a temperature as possible.

An examination of these difficulties again brings us

face to face with the four simple variables—*concentration, temperature, time,* and *pressure.* They have been applied a little differently; nevertheless they continue to be of prime importance. At times it is necessary to sacrifice the benefits of the proper manipulation of one variable for the benefits of another. It is not usually possible to derive only the good in them all. Conditions are met in both the manufacture and use of hide glue where the choice is between two evils. But develop what may, one or all of these variables, in one combination or another, must be dealt with.

The hide glue liquor from the extracting process,



Extracting Kettles.

after clarification, is pumped into a vacuum evaporator for the third step in the manufacturing process, evaporation. The vacuum evaporator removes surplus water from the hide glue liquor to facilitate handling and to save time in subsequent processes. The vacuum evaporator does two other very important things. By working under a vacuum (a pressure lower than that of the atmosphere) the temperature at which the liquor boils is held to a minimum, and a great amount of time is saved. It will be remembered that in the extracting process it was stated that four runs of liquor were taken off. All these runs must be evaporated. The question may be asked—are all four runs evaporated to the same percentage of glue? The answer is—No. Each succeeding run is evaporated to a higher percentage—and relative sets of percentages for four runs are varied as a whole to meet varying weather conditions. Lower percentages are used when the atmospheric temperature and the relative humidity are low—higher percentages are used when the atmospheric temperature and the relative humidity are high.

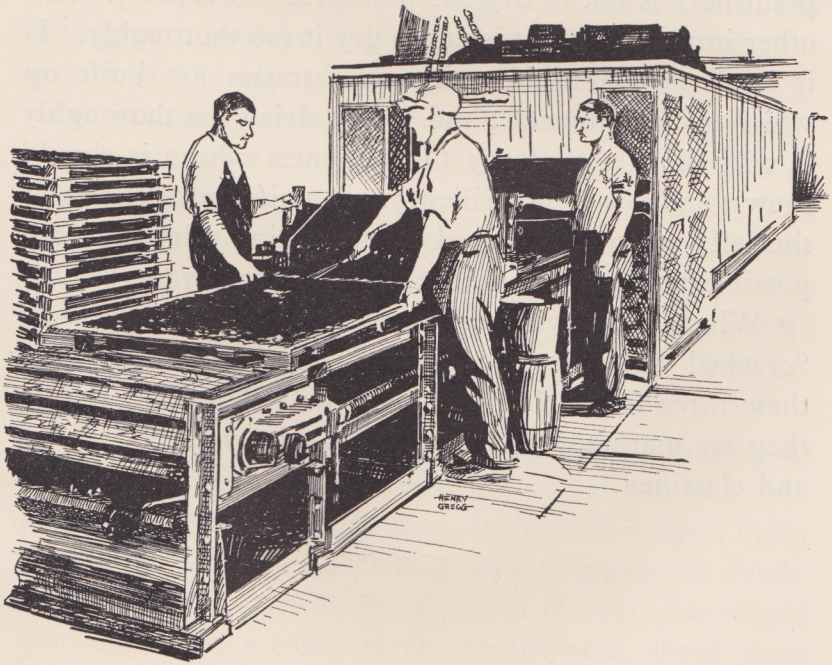
To explain adequately why these percentages of evaporation vary, it will be necessary to go back to the cooking or extracting process and further consider the time and temperature elements. During the process, four runs of hide glue liquor were taken from the same lot of stock at different temperatures, and at different times. It will be assumed that it takes six hours of heating at a constant temperature to extract the first run; that it takes

six additional hours at a higher temperature to extract the second run; that the third and fourth runs will be extracted in six hours respectively at even higher temperatures, from the same stock. Any hide glue liquor held at a high temperature for such a length of time would be degraded. So it is in all four cases. Each succeeding run will produce a lower grade of hide glue than the one preceding it, because the hide glue-stock from which it was produced has not been changed. The same stock has been under a constantly increasing temperature for a full twenty-four hour period, so from one lot of hide glue-stock four separate grades of hide glue have been produced. It is quite obvious now why these four hide glue liquors should be evaporated to successively higher percentages of glue content. Their qualities vary, progressively lower jelly strengths and viscosities and (most important) setting qualities resulting from the successive runs. The lower setting or jellying values of these four different hide glues must be taken into consideration because of subsequent steps in the manufacturing process. The higher jellying power of the first run, which is the highest grade of all, permits a low percentage of evaporation. That is—it will set as firm in a specified time as a lower grade evaporated to a higher percentage of glue content.

The variables—*concentration, temperature, time,* and *pressure* stand in bold relief in the preceding process and are prominently important in the following processes. They are ever present and cannot possibly be avoided

by either manufacturer or user—they represent the true Alpha and Omega of hide glue. It is hoped that an increasing respect for them is being developed. Their importance cannot be overestimated.

The hide glue liquor—now concentrated—is ready for the fourth and fifth steps of the manufacturing process, known respectively as spreading and drying. The liquor is cooled and run onto a long wide belt, which runs slowly through a refrigerated box in which a low temperature is maintained. When the hide glue emerges from this box, it has set to a jelly which can be handled.



Spreading, Preparatory to Drying in the Manufacturing Process.

A knife scrapes the sheet of jelly from the belt, and it is dropped onto wire-covered racks which are piled on trucks which, when filled, are run into drying alleys. A coördination of concentration, temperature, and time in the spreading of the hide glue permits the manufacturer to make all grades of hide glue of practically the same thickness. This is important, for it greatly facilitates the drying process.

The drying alleys are long rooms equipped for the circulation of an enormous quantity of air which is gradually heated as the drying proceeds. One important point here is not to dry the hide glue too rapidly. Another important point is not to dry it too thoroughly. If it is dried too rapidly, internal stresses are built up which are detrimental; and if it is dried too thoroughly it will show a tendency to brittleness where it should show toughness and resiliency. A uniform thickness of the jelly when it is placed in the drying alley makes it possible to dry the hide glue to the best advantage.

When the drying is completed, the hide glue is "cracked" into flakes and ground or pulverized. It is in these three forms that it is marketed. However, before they are marketed they must be carefully tested, graded and classified.

Chapter III

Testing, Grading, and Classifying

WHEN the manufacturing process just described is finished, PURE HIDE GLUE has been produced. But what is it? What are its characteristics? On what basis shall it be sold? These questions can be answered only by thoroughly testing, grading, and classifying the hide glues so produced. From the time the hide is removed from a slaughtered animal until the hide glue manufacturing process is completed, the reactions of hydrolysis and deterioration are constantly at work, in consequence of which the grades and characters of hide glues are constantly being changed. In view of these facts the tests, grades, or classifications of all hide glues, except tests made for plant control work, must be made after the completion of the manufacturing process. The system of testing, grading, and classifying a hide glue is quite simple but necessarily scientific and accurate.

Hide glue is used under so many varying conditions in so many types of manufacturing that it would be impossible for the hide glue manufacturer to subject every glue he produces to tests under these innumerable conditions. Yet experience over a period of years has taught the hide glue manufacturer considerable about these many uses of hide glue. Predicated on this experience a

series of physical and chemical tests has been set up to evaluate and characterize his product. In addition to these tests the hide glue manufacturer has a complete factory history of every run of hide glue he makes. He is almost on speaking terms with the very animals that give their hides to make his product. This history and the tests mentioned are correlated by him, and each and every run of hide glue is carefully classified. The classification of hide glue is vitally important—even more important than mere grade—and the hide glue manufacturer can classify only the hide glue of his own make. No amount of testing will reveal the type of hide glue-stock used in the manufacture of any particular hide glue. As the hide source determines the character of a hide glue, the source must be known before the hide glue can be classified as to type—or more correctly—as to its particular adaptability.

Laboratory, for Testing, Grading and Classifying.

Routine laboratory tests of hide glue embrace those for viscosity, jelly

strength, melting point (of jelly), moisture content, percentage and character of grease content, amount and character of foam, acidity (pH, or hydrogen ion concentration), appearance, odor, color, and keeping quality. These few tests obviate the necessity of making literally dozens of special tests, for they speak a "various language," and the hide glue manufacturer can interpret them to meet practically all demands. They are meaningless to the average user of hide glue, and really he should not be too concerned about them. They are too technical for a detailed discussion here; however, some light will be thrown upon them.

As practically every use of hide glue employs its inherent qualities of *adhesion* and *cohesion,* any system of testing or evaluating hide glue would be compelled to recognize them. In reality, the tests for *viscosity* and *jelly strength* constitute this recognition. The viscosity test, in a broad sense, is a test for adhesion; while the test for jelly strength is, similarly, a test for cohesion. In the use of hide glue, *adhesion* is the tendency of the hide glue solution to join itself with the substance with which it is placed in contact, while *cohesion* is the tendency of the hide glue molecules, themselves, to hold together. However, the popular conception of these two tests resolves itself into looking upon them as comparative tests—the viscosities showing comparative water-taking qualities, the jelly strengths showing comparative strengths and setting qualities.

Water-taking quality, unfortunately, has two meanings, and they are confusing. The one referred to here concerns itself with the amount of water that must be added to a hide glue to bring it to a specified consistency of solution. The other interpretation is the amount of water a hide glue will soak up and hold within itself. Previous to recent improvements in both the manufacturing process and the system of testing the latter interpretation was considered of vital importance in the selection of a hide glue. Today, it is seldom resorted to—in fact, any consideration it may receive is extraneous, because this "swelling" is accounted for in other tests which are far more reliable.

The tests for viscosity and jelly strength are by far the most important tests of hide glue. In addition to being tests for adhesion and cohesion, or solution consistency and strength, they are the only tests used in arriving at the grade of a hide glue. It is important to remember that these two purely physical tests are the only ones used in determining the grade of a hide glue; and that the grade determines the price the user shall pay. All other tests are immaterial in so far as grade and price are concerned. However, they are very important in characterizing hide glue for classification into types.

The *melting point* test of a hide glue jelly, in a way, is an attempt to establish a relationship between the tests for viscosity and jelly strength. This test is still in its infancy; but, in spite of that, it has great possibilities as

a medium of expressing adhesive strength. After the completion of more research this test will, undoubtedly, be well regarded in the evaluation of any hide glue.

Moisture is present in hide glue in varying amounts. If accurate determination of viscosities and jelly strengths are to be made, this variation in moisture content must be compensated for. In other words, all tests, if the results are to be accurate, must be made on the basis of an established moisture content of the hide glue to be tested.

If *grease* tests on hide glue are to be of real benefit, they must show both the amount of grease present and the character of the grease. Grease may be present as a calcium (lime) soap, as a free grease, or as an emulsion. The form in which the grease is present is a determining factor in the selection of hide glue for all types of work.

Any *foam* test for a hide glue, to be adequate, must consider the character of the foam, as well as the amount of foam generated. Foam is usually looked upon as a necessary evil in hide glue; but, in many uses of hide glue, foam is an absolute necessity. Until very recently, the test for foam received only cursory consideration. It is today receiving the attention it merits and is the means of solving many problems that were once approached with trepidation.

The test for *acidity* (pH or hydrogen ion concentration) is a test of great importance in a study of the properties of hide glue. In years past litmus paper was used in tests for acidity and alkalinity. This test was crude

and unreliable. When a system was devised by which very low acid concentrations could be detected, it relieved the hide glue manufacturer of many burdens. It helped him in the evaluation of his product, but of greater importance was its effect on his manufacturing process. It permitted control of basic reactions to a very fine degree, in consequence of which there is now more uniformity of types of hide glues than was possible before its adoption, and they are cleaner and sweeter.

The *appearance, odor,* and *color* of a hide glue cannot be considered tests in the larger sense. They are merely observations, and are taken as a preliminary step. To the experienced observer these observations may mean much; for they may lead him directly to the discovery of deficiencies or adulterations, the existence of which he can substantiate by special tests, and no one experienced in the ways of hide glue would commit himself without such substantiation.

The test for the *keeping quality* of a hide glue is really a fermentation test which is usually carried on over a period of 72 hours at a temperature that will best develop bacterial decomposition. Observations are usually recorded every 24 hours, and the solution carefully examined and tested at the end of the 72-hour period. Under present plant control methods used during the manufacturing processes, very few hide glues fail to pass this test.

It was stated earlier that the tests to which a hide glue is subjected were meaningless to the average user

and that he should not concern himself about them. A great deal of misunderstanding can be avoided if the interpretation of these tests is left in the hands of the hide glue manufacturer. Enough information has been given here to place the user in a better position to ask questions—and to better understand the answers to those questions.

Great strides have been made in recent years in the perfection of this system for testing, grading, and classifying hide glues; and the user has been materially benefited. The hide glues he is using today are better made, and his shipments are far more uniform in both grade and character. But the system is only efficacious when interpreted by the hide glue manufacturer himself. He, and only he, knows the pitfalls of misinterpretation.

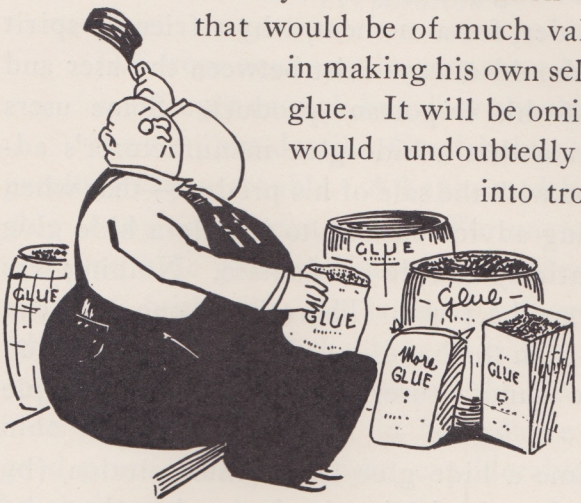
Chapter IV

Selection

BECAUSE there are several grades of hide glue—and because each grade has a multiplicity of distinct types—the proper *selection* of a hide glue for use in woodworking is a difficult task for any user. Unless the user consults a hide glue manufacturer, the selection will in all probability lead to dire results. If the user will lay his complete case before a reputable hide glue manufacturer, and allow him to make the selection, the chances for a lasting satisfaction will be far better than if he, himself, makes the selection from the results of even scores of tests of as many different hide glues. The selection of hide glue is almost an art. It requires the skill born of years of experience and should not be considered lightly.

True—any hide glue, if all gluing conditions are perfect, will make a joint that will give a shearing strength stronger than the strongest wood. But gluing conditions are rarely, if ever, perfect; and it is the weaknesses and imperfections of these conditions that must be taken into account in the selection of the "best" hide glue. The hide glue manufacturer, alone, knows the limitations of his product; and only he can make a selection of a hide glue that will give the "last full measure of devotion" yet retain an ample margin of safety. It is important—

and advisedly so—that, if the selection of the best hide glue for any purpose is to be made, the user and manufacturer must coöperate to the fullest extent.



Selection Is Important!

Very little information could be given that would be of much value to any user in making his own selection of a hide glue. It will be omitted here, for it would undoubtedly get the user into trouble. The old adage that a "little information is a dangerous thing" was never more applicable than it is in this connection. The only advice that will assure satisfaction and safety in the selection of a hide glue is for the user to coöperate with a responsible and reputable hide glue manufacturer and insist upon PURE HIDE GLUE of a grade and type that will give optimum results when put to work at its appointed task.

After the proper hide glue has been selected, we are ready to put it to work. Hide glue has many moods. It can be a loyal friend or a virile enemy. Its attainment of the mood that is desired is, almost entirely, dependent upon the user. There is little to fear from properly selected hide glue. What the user does with it decides, in

main, what the results will be. If he "hews to the line" he will be rewarded with strong glued-joints—glued-joints that will be permanently strong.

Before proceeding to the preparation and use of hide glue, let us consider, for a moment, why a friendly spirit of coöperation should always exist between the user and manufacturer of this important product. Some users are of the opinion that a hide glue manufacturer's advice should cease with the sale of his product—that when it comes to giving advice on how to handle a hide glue solution he is entirely outside his domain. Nothing was ever farther from the truth. There is no one who can give better advice in the handling of a hide glue solution than a hide glue manufacturer—and the reason is simple and logical.

From the time a hide glue is put into solution (by heating) until the glued-joint is thoroughly dry, the problems met by the user are identical with the problems encountered by the hide glue manufacturer in his manufacturing processes, and the answers to these problems are to be found somewhere among the simple variables of *concentration, temperature, time,* and *pressure.* Who is better equipped to solve these problems than the hide glue manufacturer himself? He has been in the midst of these variables for years and is thoroughly familiar with their idiosyncrasies as they concern hide glue.

CHAPTER V

Preparation

THE steps necessary to prepare a hide glue for use are simple enough but, they should be followed to the smallest detail. Good habits cultivated early preclude future trouble. A haphazard handling of hide glue at any time is dangerous. Fortunately for the average user, hide glue will take a great deal of abuse and yet work faithfully; but let us not forget that there is "the last straw," and that when trouble strikes it leaves only more trouble in its wake. If the preparation of hide glue is carried out in accordance with accepted good practice as given here, considerable difficulty will be obviated.

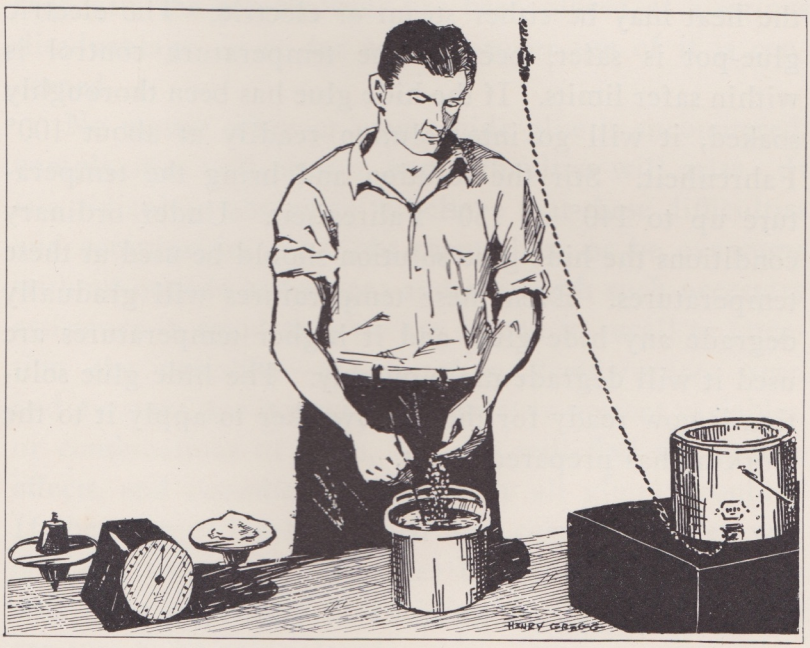
Weighing, soaking, and *melting* of a hide glue are so closely related that it is probably best to consider them together. They constitute preparatory processes. As the results to be later attained or expected are dependent on them, they must not be considered lightly.

Before we discuss these preparatory processes in detail, it will be necessary, first, to ascertain what proportions of hide glue and water will produce the proper consistency of solution for the work at hand. This point can best be settled by consulting with the hide glue manufacturer. After arriving at what are about the correct proportions the user may make some actual tests. These

tests should be made with solution consistencies thinner and thicker than that recommended. For example, it may be decided by agreement that the "water-hide-glue ratio" should be 2 to 1 (2 parts of water by weight, to every part of hide glue, by weight). The tests should then be made on successive ratios such as 1½ to 1, 1¾ to 1, 2 to 1, 2¼ to 1, and 2½ to 1. Very illuminating information can easily be procured by employing woods of varying types and densities in the tests with these different consistencies of solution. After the tests are finished the user will be fairly well on the road to better acquaintanceship with his hide glue, for he will have learned considerable regarding its limitations. Once the ratio (concentration) has been decided upon it need only be changed to compensate for any changes in the variables of *temperature, time,* and *pressure* wherever they may occur in the assembly process.

PURE HIDE GLUE as it is received by the user may be either in the flake or ground form. The ground form is the more popular and decidedly the easier and safer to use. The first step in the preparatory process is to *weigh* both the hide glue and water, and it is very important that only pure cold water be used. Never measure the proportions—always weigh them. Never trust the eye in mixing hide glue. Few hide glue users have stopped to realize that a light-colored solution will always appear to the eye to be thinner than a dark-colored solution of identical consistency. This is ordinary optical illusion, and it can cause much trouble.

After the amounts to be used are weighed, they are mixed for soaking. *Never add water to a hide glue—always add the hide glue to the water.* This will prevent the forming of balls which will fail to go into solution, thereby lowering the concentration of the remaining solution. Place the soaking-vessel in a cool place and allow it to stand overnight. Some say that a ground hide glue can be properly soaked in from one to two hours. This may or may not be true, but if it is soaked overnight it will go into solution with the minimum amount of heat, and the dispersion will be better. This saves time and protects the strength of the solution be-



Proper Method of Mixing Glue.

cause prolonged heating degrades hide glue by a stimulation of hydrolysis. A note of warning must be sounded here. All receptacles used for hide glue should be kept very clean at all odds and at all times.

If large batches are soaked, the soaking-vessel should be covered to prevent evaporation. It is surprising how much water can be lost overnight from a large open soaking-vessel or tub. This evaporation changes the intended concentration and is an outright loss.

The final preparatory process is the *melting* of the hide glue. After the hide glue has been thoroughly soaked, it is placed in a water-jacketed container where the heat may be either steam or electric. The electric glue-pot is safer, because the temperature control is within safer limits. If the hide glue has been thoroughly soaked, it will go into solution readily at about 100° Fahrenheit. Stir the solution and bring the temperature up to 140° or 150° Fahrenheit. Under ordinary conditions the hide glue solution should be used at these temperatures. Even these temperatures will gradually degrade any hide glue, and if higher temperatures are used it will degrade more quickly. The hide glue solution is now ready for the woodworker to apply it to the work he has prepared for it.

CHAPTER VI

Use of Hide Glue in Woodworking

HIDE glue in the hands of a woodworker is purely a tool, and if success in its use is to be achieved it must be accorded the respect other woodworking tools command—and usually receive. A woodworker should be as thoroughly acquainted with his hide glue as he is with his other tools. Unfortunately general information about hide glue has been meager; and consequently the woodworker has been placed at a serious disadvantage, in so far as the proper use of it is concerned.

No matter when or where hide glue is encountered, complexities will be met, and difficulties will arise. It is a ridiculous absurdity to believe that these difficulties and complexities can right themselves, or be overcome without outside assistance; and it is with such necessary assistance in mind that we are forced to recall to attention the variables—*concentration, temperature, time,* and *pressure,* for it is within these ever-present variables, or combinations of them, that we will find the causes, effects, and remedies of practically all gluing troubles. If they are properly applied and correlated, they will not only overcome difficulties that will arise but they will assist materially in avoiding the complexities that are sure to be encountered.

From the woodworker's viewpoint there are only two primary materials used in making a strong and permanent glue joint, namely, hide glue and wood. Both of these materials have many variables. These variables can be controlled. The simple secret of making good "glued-joints" is to coördinate these variables. This can be done in two ways. The hide glue solution can be varied to meet wood conditions, or the wood conditions varied to meet the conditions of the hide glue solution. The characteristics of a hide glue solution are so much more flexible than those of wood that to meet existing conditions at almost any time it is easier to vary the hide glue solution. However, wood conditions should be kept within reason.

Hand Application of Glue.

When and if "glued-joints" fail, the best place to look for the trouble is, of course, at the "glue line," and the observations should be made both before and after pressure is applied. A thorough examination of conditions at this point will reveal one of the following results of poor gluing practice:

(1) A Chilled Joint; (2) a Starved Joint; or (3) a Dried Joint. All of these are weakened joints, and if strong joints are the results to be attained (and most assuredly they are), then the causes leading to them must be avoided. It will be less confusing and more informative to discuss these results of poor gluing practice by first examining their causes and considering later the remedies necessary to produce results commensurate with good gluing practice.

A *"Chilled Joint" is a glued-joint in which the hide glue applied has chilled to a jelly at the glue line, either before or after the application of pressure.* The contributory cause or causes responsible for this condition may be any one, or any possible combination, of the factors within the variables—*concentration, temperature, time,* and *pressure,* and are as follows:

CONCENTRATION—

1. Not enough water present in the hide glue solution,
2. Hide glue film too thick,
3. Relative humidity in glue room too high,
4. Too high a moisture content in wood,
5. Density of the wood too high;

TEMPERATURE—

1. Temperature of the hide glue solution too low,
2. Glue room temperature too low,
3. Glue room drafty,
4. Wood too cold;

TIME—

1. Too much time consumed in assembly,
2. Hide glue setting too quickly;

PRESSURE—

1. Insufficient pressure applied,
2. Pressure released too soon.

When it is fully realized that these factors and all possible combinations of them will run into the hundreds; and that each factor or combination is a potential trouble-maker, it will become apparent at once why we continually speak of "difficulties" and "complexities."

A *"Starved Joint" is a glued-joint in which there is insufficient hide glue present at the glue line, either before or after the application of pressure.* Factors of *concentration, temperature, time,* and *pressure* are also operative in causing this condition. However, in this case the factors are, for the most part direct opposites of those responsible for a chilled joint, and are as follows:

CONCENTRATION—

1. Too much water present in the hide glue solution,
2. Hide glue film too thin,
3. Hide glue soaked or mixed improperly,
4. Too low a moisture content of wood,
5. Density of wood too low,
6. Gluing two woods of high and low densities;

TEMPERATURE—

1. Temperature of hide glue solution too high,
2. Glue room temperature too high,
3. Wood too hot;

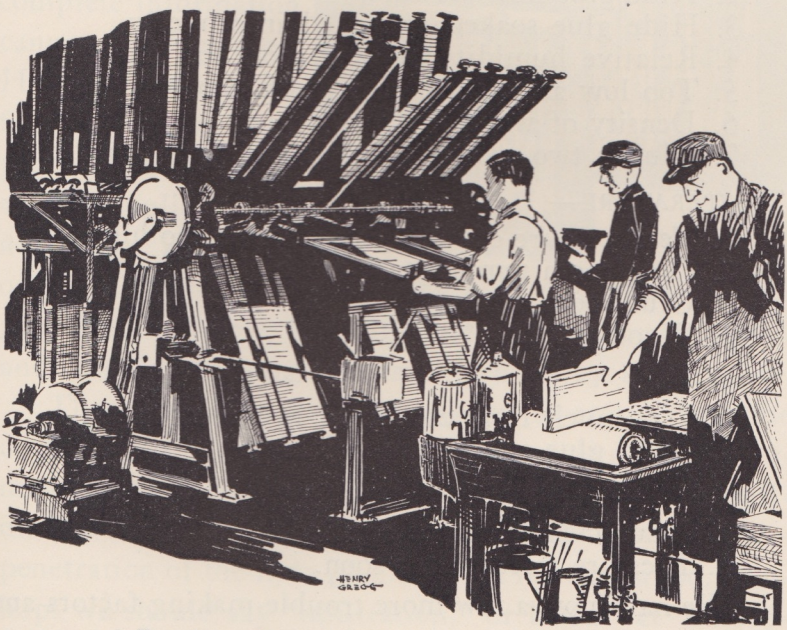
TIME—

1. Not enough time consumed in assembly,
2. Hide glue setting too slowly;

PRESSURE—

1. Too much pressure applied.

We are faced again with factors and combinations of them that can be counted in hundreds, and they are as troublesome as those causing the "chilled joint" con-



Revolving Clamp and Mechanical Spreader.

dition. You will agree that our gluing problem is growing more complicated by leaps and bounds.

A *"Dried Joint" is a glued-joint in which the hide glue applied has dried at the glue line, either before or after the application of pressure.* Factors of *concentration, temperature, time,* and *pressure* also contribute to this condition. It is at times difficult, if not impossible, to differentiate a "dried joint" from either a "chilled joint," or a "starved joint." The causal factors that must be dealt with in this instance are:

CONCENTRATION—

1. Too much water present in hide glue solution,
2. Hide glue film too thin,
3. Hide glue soaked or mixed improperly,
4. Relative humidity of glue room too low,
5. Too low a moisture content of wood,
6. Density of wood too low,
7. Gluing two woods of high and low densities;

TEMPERATURE—

1. Temperature of hide glue solution too high,
2. Glue room temperature too high,
3. Glue room drafty,
4. Wood too hot;

TIME—

1. Too much time consumed in assembly,
2. Hide glue setting too quickly;

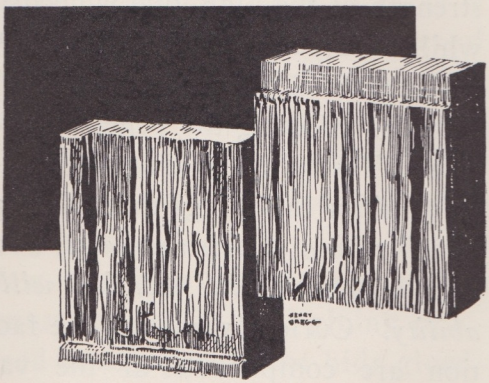
PRESSURE—

1. Insufficient pressure applied,
2. Pressure released too soon.

We have now a few more trouble-making factors and combinations to add to those already recorded. All in

all we are face-to-face with a problem that has all the earmarks of being a very complicated one. However, do not despair. This formidable array of "effects" and "causes" has reasonably simple "remedies." If both feet are kept on the ground and the head on the shoulders, there is no great cause for fear.

If the hundreds of factors and their combinations responsible for *chilled, starved,* and *dried* joints were to be discussed one by one and remedies given for each case, volumes would be necessary. It is regrettable that this complete information cannot be presented. However, general information can be given here, which, if sanely applied, will not only keep the ordinary user of hide glue out of trouble, but will render him valuable assistance should his judgment lead him astray temporarily.



Wood Fails—Pure Hide Glue Holds.

The result a woodworker wishes to attain from the combination of his hide glue and wood is a strong permanent union or joint. The success of his efforts is primarily dependent on what we shall call—*penetration*—penetration of the hide glue solution into the wood. Perhaps we should say "infiltration," or better yet "absorption." We use the word *penetration* because it expresses

more simply, and fairly truthfully, what actually takes place at the glue line. There must be a *penetration* of some sort—how much cannot be stated with any degree of accuracy. We must not forget that after all it is the "adhesive" and "cohesive" strength of the hide glue that controls ultimate joint strength, and for that reason we must be ever careful and not demand, in any manner whatsoever, a penetration that will force the hide glue solution too far away from the glue line where the strength of the hide glue is needed. If glued-joints fail while using a good PURE HIDE GLUE, the woodworker should first of all ask himself the question—What is affecting the penetration of my hide glue solution? To assist in answering this pertinent question let us consider the things that affect penetration.

Anything which increases, decreases, or inhibits the flow of a hide glue solution will affect its penetrating ability. Curiously enough the factors affecting penetration are components of the variables *concentration, temperature, time,* and *pressure;* and these variables, in turn, affect one another. However complicated the approach may seem, always coolly search for something that will impede penetration. Finding it will simplify the problem materially.

It takes little imagination to recognize the following facts: That a thick hide glue solution will not penetrate a dense wood to the same degree as a thinner solution, and that a thin hide glue solution has a tendency to penetrate too deeply into a porous wood; that insufficient

pressure is not conducive to what we believe to be proper penetration, and the application of an excessive pressure may, if the hide glue solution is thin, result in excessive penetration; that a wood which is dry will require for proper penetration a heavier concentration of hide glue in solution than a wood which has a high moisture content; that it is ridiculous to assume, if so much time is consumed in assembling glued pieces as to permit the hide glue solution to chill or dry, that any amount of pressure will result in enough penetration to make a bond; that if the wood is cold and the temperatures of the glue room and the hide glue solution below what they should be a chilled joint is to be expected, for pressure cannot possibly produce penetration with a hide glue jelly. And so it goes on and on: problem after problem, one complication after another. It is hoped, however, that these few examples will convey to the user the method that must be used if good gluing practice is to be attained and strong permanent hide-glued-joints made. Of course, it required reasoning, but it is common-sense reasoning not based on any special technical education.

If all elements conducive to proper penetration are in order, there is only one other troublesome item to consider, and that is—*time*—the time the joint is under pressure, and the time allowed for drying between the release of pressure and further tool or machine work. Pressure should be continued until the hide glue has set sufficiently to hold the joint in place without assistance.

After pressure is released, the joint should be thoroughly dried before it is subjected to the stresses and strains of additional tooling or machining. Thoroughly drying, however, does not mean driving out all moisture present in the wood or in the hide glue at the glue line. If it is dried to what might be called a normal room humidity it will be sufficient. Unless it is dried to this point before the last machining is done, "sunken joints" or more aptly "shrunken joints" will develop. The drying should be carried on at a gradual rate, at about room temperature, to prevent stresses being built up in the hide glue at the glue line which would naturally weaken the joint.

We have now considered fully, but necessarily briefly, the effects of poor gluing practices, and we have given a rather extensive outline of the elements responsible for these effects and coordinated these elements in their proper relation with the important and ever-present variables *concentration, temperature, time,* and *pressure.* There is no denying that the problems which arise in the use of hide glue are complicated. Much of this complication is due to the fact that so little is actually known of the phenomena of hide glue—what it actually is and why it acts as it does. The technology of hide glue is still in its infancy. What we know about it we know only in a practical way—and consequently in dealing with hide glue problems we must approach them in a practical, common-sense manner. If all woodworkers will consider the problem in this light, their difficulties will fade, and a new day will dawn in which hide glue

will be a tool that will be used with the same aplomb and respect their other tools receive. Assuming this breadth of mind on the part of the woodworker, we can safely suggest general remedies which, if applied, will prove very helpful. It is not proposed, however, that they be considered a panacea for all hide glue troubles. They must be used with discretion at all times.

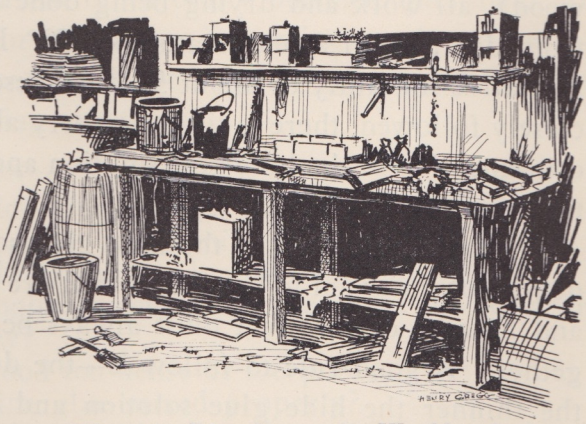
CHAPTER VII

Remedies for Glue Troubles

INASMUCH as our discussion of hide glue up to this time has made frequent use of the variables *concentration, temperature, time,* and *pressure* it is only fitting that, as we now come to the point where it is necessary to consider remedies which will assist us in overcoming or avoiding the evils previously outlined, we consider them as they are related to these ever-present and important variables. However, these remedies must be accepted only in a general way and be used with prudence. At times conditions will make it necessary to sacrifice the benefits of one for the benefits of another. In our discussion of these remedies we will attempt to show how a woodworker should choose and use them to the best advantage in a practical way. If the woodworker is to profit from this discussion, it will entail careful study on his part; but he should not be apprehensive. The subject, while complicated, demands only a common-sense reasoning to simplify it.

When we discussed the effects of poor gluing practices, viz., *chilled joints, starved joints,* and *dried joints,* we considered their causes and learned that these causes were the result of factors and combinations of factors within the variables *concentration, temperature, time,* and *pressure,* and we found many trouble-making fac-

tors and combinations of them. Later we simplified matters materially when we stated that successful effort in gluing was "primarily dependent on—*penetration.*" We amended this statement somewhat when we referred to "infiltration" and "absorption." It has never been actually proved just what takes place at the glue line and just what facilitates the reaction between hide glue and wood. There are several theories, and all of them are reasonable in part. We suggest a sensible middle course and prefer to refer to it as "penetration," believing the word to be more expressive of what happens and more truly representative of the concensus of reliable opinion than any statement of theory could be. As we go into our remedial discussion, let us remember the importance of *penetration,* and that *anything which increases, decreases, or inhibits the flow of a hide glue solution will affect its penetrating ability.*



Wrong!—Disorder at the Workbench.

Our problem will be simplified to even a greater degree if we convert some of the variable factors of *concentration, temperature, time,* and *pressure,* with which we

must deal, into constants or standards of action. This, in fact, is the general procedure. It is a maxim of good gluing practice that best results are attainable, in general, when a hide glue solution at 140° to 150° Fahrenheit is applied to wood with a 5% to 6% moisture content, and a temperature of 70° to 90° Fahrenheit, and a pressure of 100 to 200 pounds per square inch applied (depending on the construction and the fibre and density of the wood), all work and drying being done in a room free from drafts with a temperature of 70° Fahrenheit and a relative humidity of about 50. If these standards are closely followed, there is little to worry about except the concentration of the hide glue solution and the density of the wood.

The concentration of the hide glue solution and the density of the wood to be used with it are interdependent and because of that fact must always be considered together. A good rule to follow is—the denser the wood the thinner the hide glue solution and the higher the grade of hide glue to be used. Correct concentration (water-hide-glue ratio) can be learned only by test as outlined in Chapter V. In arriving at the correct concentration always weigh both hide glue and water, and always maintain the same temperature. This is very important, because a light-colored hide glue solution will always appear to the eye to be thinner than a dark-colored solution, and because a variation in temperature will vary inversely the solution consistency (the higher the temperature the thinner the solution consistency).

If the standards set forth here are observed, the woodworker need never worry about the strength of his glued joints. But this isn't always possible, and at times it becomes necessary to sacrifice benefits "here" for more important benefits "there." It is surely obvious by now that it would be next to impossible to give a rule for every deviation that might be made from accepted good gluing practices. However, to assist the woodworker, we give here a list of carefully outlined questions. If trouble arises or if changes in routine are found necessary or expedient, it will be helpful if you will ask yourself the following questions:

CONCENTRATION—

1. Is the hide glue solution too thick or too thin?
2. Is the weather too humid or too dry?
3. Is the glue room too humid or too dry?
4. Is the moisture-content of the wood too high or too low?
5. Is the wood too dense or too porous?
6. Is the hide glue mixed properly?
7. Is the hide glue film spread too thick or too thin?

TEMPERATURE—

1. Is the hide glue solution too hot or too cold?
2. Is the glue room too drafty, too hot, or too cold?
3. Is the wood too hot or too cold?

TIME—

1. Is the hide glue soaked long enough?
2. Is the hide glue solution fresh, or has it been under heat or in use too long?
3. Is the hide glue setting too fast or too slowly?
4. Is the assembly too fast or too slow?

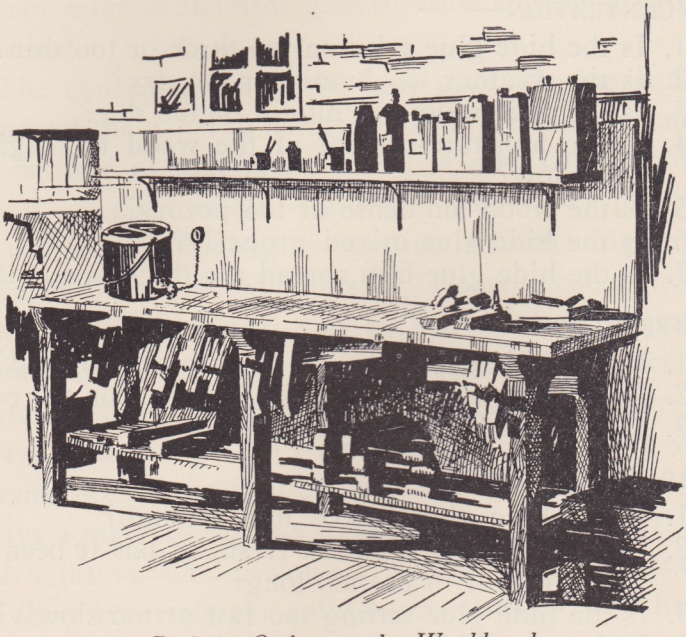
5. Is the glued-up stock dried long enough before further machining?

PRESSURE—

1. Is the pressure excessive or insufficient?
2. Is the pressure applied evenly along the glue line?

In addition to these questions concerning *concentration, temperature, time,* and *pressure,* it will also be necessary to consider the following questions:

1. What grade of machine work is being produced?
2. What type of joint is being used—plain, tongued-and-grooved, or rip-saw joint?
3. What construction is used—edge gluing, face gluing, butt-end gluing, or a combination of these?



Right!—Order at the Workbench.

4. Are woods of varying densities being glued to one another?

We realize full well that this sounds like a huge undertaking, but in reality it is not so difficult and complicated as it appears. If the woodworker will consider these questions in a perfectly common-sense manner, as they apply to the increase, decrease, or inhibition of flow of a hide glue solution—to those things affecting the penetrating ability of the hide glue solution—he need not be apprehensive about his glued joints. The *standards of action* we outlined are fairly definite, and yet the freedom of action allowed gives plenty of room to maneuver to advantage in almost any particular eventuality.

There is no denying that the use of a hide glue is fraught with complications, but they are not so difficult —rather easy to deal with, in fact—if they are considered separately instead of collectively. The questions propounded have answers. For the most part we have refrained from answering them directly for two reasons: First, because space did not permit; Second, because "knowledge earned is knowledge learned"—because the answers are within your own grasp, and there is no help like self-help. If the answers are not forthcoming, it is then time to ask the hide glue manufacturer for his assistance and interpretation.

CHAPTER VIII

Use of Hide Glue in Other Industries

TO THE woodworker the importance of hide glue is very apparent as it concerns him at every stage in his operations. It is just as important in the many other lines of industrial activity in which it is employed. Hide glue has so many uses that it may be said to represent the acme of utility. The rôles it can play in the drama of industry are several, and peculiarly enough it is possible for one particular hide glue to play each rôle in turn with remarkable ability and equal satisfaction. It can assume the rôle of an adhesive, a binding agent, a sizing agent, a colloidal gel, or a protective colloid whenever required.

Hide glue is probably known best as an *adhesive,* because its inherent abilities connote adhesiveness. It is in this rôle that we meet it in all woodworking industries; in the manufacture of paper products such as boxes, tablets, pads, and spiral or laminated tubing used in making cartons and containers; in the book bindery where it is used in making the case (cover) as well as in the binding itself; in the manufacture of frosted glass; in the compounding of special cements, and in the formulating of all types of Pure Hide Liquid and Flexible Glues.

Closely akin to the use of hide glue as an adhesive is

the rôle it plays as a *binding agent.* We find it here as the star actor in the manufacture of all types of matches; in the making of abrasive paper and cloth; in the setting-up of abrasive wheels and belts for the polishing of metals previous to buffing or electro-plating; in the combination of materials used for composition mouldings and statuary, and in the manufacture of "composition cork" used for gaskets and inserts in jar and bottle crowns (caps).

Hide glue as a *sizing agent* steps out of its usual character to show us how talented it really is. It is here it attains great heights in daily usefulness in the manufacture of the highest grades of crêpe, ledger, bond, blue-print, and writing papers; in the fabricating and finishing of textiles—especially high grade silks; in the manufacture of hats and shoes; in the manufacture of wooden containers for liquids; in interior decorating, paints and calsomines; in the manufacture of fly paper and window shades, and, in many other industries where real quality of sizing is essential.

It is an unusual rôle that hide glue plays as a *colloidal gel*—and a very important one. The development of the printing press and the success of printing, especially the quality of the work and the speed at which it could be economically produced, were entirely dependent upon the discovery of a pliable roller of the proper ink carrying ability and with just the necessary elasticity to best convey the ink to the type. It was found that a mixture of hide glue, molasses, glycerine and other ma-

terials best answered the purpose and that a variation in the proportions of materials used would result in the making of rollers of varying characteristics to be employed on different types of presses and for different grades of work. To this very day the printers' roller with a hide glue base stands as an unique feature of the developed printing press. Its supremacy has been challenged many times, but it has yet to be replaced—indeed, a noble contribution to civilization.

Glue Has Been Used More Than 90 Times in This Scene.

The rôle hide glue will eventually play will be that of a *protective colloid,* and it is in this future rôle that it will no doubt accredit itself with even a more useful fame. In past performances hide glue has exhibited its physical character, but as a protective colloid it will reveal its innermost chemical nature. The chemistry of colloids has not advanced far enough to permit us even to conjecture the future possibilities of hide glue. From its earliest beginning hide glue has been the key that continually opened "future's portal," and there is no reason to believe that the last portal has been opened. When other gates bar the advance of civilization we may

reasonably look for hide glue to step forward to lead us through—and on.

As we go onward we will continue to meet the same hide glue problems—perhaps in just enough of a different light to render them confusing, but nevertheless in essentially identical form. What you have learned here of hide glue—its manufacture, testing, selection, preparation, and use—may be applied wherever hide glue is encountered in the many different lines of industrial activity. No wonder that hide glue may be said to head the list of "things useful to man"—that its manufacture and use are unusually interesting in spite of their complexities.

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KEYSTONE GLUE COMPANY
WILLIAMSPORT, PENN.
Manufacturers of PURE HIDE GLUE Exclusively

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GLOSSARY

acid—any sour substance, or, specifically, a chemical compound of hydrogen characterized by sourness, by capability of decomposing most carbonates, and generally by solubility in water.

acidity—condition or quality of sourness, or the degree of acid strength.

acidulation—process or result of increasing the acidity or sourness of a substance or solution.

adhesion—tendency or result of molecular force causing one body to stick to another body (see *cohesion*).

albumin—proteid substance found in the blood and many other animal and vegetable liquids and solids, soluble in water and coagulable by heat, alcohol, or strong acid.

albuminous—containing or resembling albumin.

alkali—chemical compound like lime or magnesia characterized by solubility in water and capability of neutralizing an acid.

alkalinity—condition or quality of being alkaline, or the degree of alkaline strength or lack of acidity.

bond—that which binds or holds two parts together (see *joint*).

butt-end gluing—process or result of gluing together two pieces of wood or other material placed end to end or with a butt-end against a side or face.

calcium soap—soap in which lime furnishes the alkaline element.

ceramics—art of molding, modeling, baking, and finishing articles made of clay.

chilled joint—a joint in which the glue intended to form the bond has become cold.

cohesion—tendency or result of molecular force causing particles of a single substance to stick together (see *adhesion*).

collagen—the protein from which glue is produced.

colloid—compound or substance like glue which after setting can be redissolved by warming or diluting, or one like albumin which after setting can not be redissolved.

colloidal gel—a precipitate resulting from the agglomeration and precipitation of colloidal particles.

concentration—process or result of evaporating a solution to a greater density; degree of density in the resulting substance.

constant—property of a substance that remains always the same under the same conditions while other properties vary.

corium—layer of skin beneath the epidermis.

dense stock—hard wood of a fine grained texture tending to hinder absorption.

dried joint—a joint in which the glue intended to form the bond has dried.

drying alley—a room in the glue manufactory where the hide glue is dried preparatory to grinding.

edge gluing—process or result of gluing together two pieces of wood or other material placed edge to edge or with an edge against a side.

emulsion—liquid mixture in which a fatty or resinous substance remains suspended in minute globules.

epidermis—outer layer of the skin.

evaporation—process of drying or concentrating a substance by expelling moisture from it in the form of vapor.

extracting—process of separating one substance from another by cooking, distillation, pressure, or solution.

extracting kettle—vessel in which the process of extracting is carried on by solution and cooking.

face gluing—process or result of gluing together two pieces of wood or other material placed side by side.

free grease—superfluous fat separated by extracting or remaining after a portion of fat has entered into a compound.

gelatin—hard, transparent, tasteless substance extracted by the action of hot water on connective animal tissue, and used in various forms, as sizing, isinglass, or food, in the manufacture of photographic plates and films as a basis for bacteriological cultures, and for other purposes.

glued joint—joint in which glue forms the bond.

glue-film—thin layer of glue spread upon a surface to form the bond of a joint or for other purposes.

glue-line—the line of contact of materials where glue is applied.

glue-stock—hides and pieces of hide from which glue may be extracted.

grade—degree of excellence of a product measured by its behavior or qualities shown in use.

grease content—quantity of grease remaining in a product.

hide-glue—glue made only from the hides of animals.

hide-glue liquor—solution of gelatinous and other substances resulting from the cooking of glue-stock.

hide-tissue—cellular fabric of hide.

humidity—amount or proportion of water-vapor present in the air.

hydrogen ion concentration—chemical condition resulting in increased acidity.

hydrolysis—chemical decomposition of a compound that results from its absorption of water, causing formation of a new compound.

hydrolyzing—process of producing hydrolysis.

jelly strength—the consistency of a glue jelly; a definite test used for evaluating and grading glue.

keeping quality—ability of a substance to remain more or less permanently without deterioration.

liming—process of applying lime to a substance or material.

litmus paper—bibulous or absorbent paper dipped in a solution of lichen dyestuff which turns red when acted on by an acid and returns to its original blue color when heated with an alkali, used to determine whether a solution is preponderately acid or alkaline.

margin of safety—excess of strength over what would be needed to meet an ordinarily expected strain.

melting point—degree of temperature at which a solid becomes liquid.

membrane—thin, sheet-like, usually fibrous structure connecting other structures or covering or lining some organ or part of the body.

moisture-content—amount or proportion of water present in any substance.

molecule—smallest part of a substance that can exist separately and still retain its composition and properties; the smallest combination of atoms that will form a given chemical compound.

mucin—slimy, proteid substance found in mucus or phlegm or other bodily secretions.

mucinous—resembling or containing mucin.

optimum results—the best results capable of attainment in any given situation or process.

penetration—process or result of entering into or becoming diffused among the cells of animal or vegetable tissue or the porosities of mineral matter.

plain joint—a joint in which the edges are machined plain, or flat.

porous stock—soft wood of a coarse-grained texture tending to expedite absorption.

protective colloid—a water-peptizable colloid that will peptize precipitates and prevent the agglomeration and consequent settling of finely divided precipitates.

protein—albuminous compound derived from a combination of carbon, hydrogen, oxygen, nitrogen, and sulphur, found in all animal and vegetable organisms.

rip-saw joint—a joint made from wood coming direct from straight-line rip saw without further machining.

run—process or result of cooking glue-stock in water for a length of time before the water is changed.

saponification—process or result of making soap, a chemical decomposition in which compound ether is changed into an acid and an alcohol.

setting—process or result of a liquid's hardening into a solid.

shearing strength—resistance to forces tending to make two surfaces slide upon each other.

shrunken joint—a joint which has shrunk along the glue-line (see *sunken joint*).

soaking-vessel—vessel in which material is soaked in liquid.

solution—liquid combination of a liquid and a non-liquid substance.

starved joint—joint put together without sufficient glue at the glue line to serve as a bond.

sunken joint—a joint which, due to shrinkage, has sunk along the glue-line (see *shrunken joint*).

tanning—process of converting hides into leather.

tongued-and-grooved joint—joint in which the bond is strengthened by cutting the material at the point of union so as to increase the area of the adhering surfaces.

type—classification based on the quality of stock entering into manufacture.

union—joint secured by a bond.

vacuum evaporator—a device for removing moisture from a substance by means of exhausting the air from the vessel in which it is contained.

veneering—process or result of fastening a thin layer of material to the surface of another material.

viscosity—state, quality, or property of being thick, sticky, or gummy.

wash-mill—a device for washing materials by means of rotary motion.

water-taking capacity—quality or condition of a material which causes it to absorb water; the degree of such absorption.

water-hide-glue ratio—proportion of water to hide-glue in a solution.

water-jacket—outer vessel containing water in which an inner vessel is placed to prevent its contents from coming in contact with the water.

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* Note: The variables *concentration, temperature, time,* and *pressure* are used so often in the text that indexing all references to them would be confusing. To obviate this confusion their importance is only referred to as stressed in the Foreword.

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* *Ibid.*, see p. 61.

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* *Ibid.*, see p. 61.

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